IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Reissue Application of Yousheng Shen, et al.
Application No. 10/621,637
Filed: July 17, 2003
For: U.S. Patent No. 5, 650,054

MERGED PROCEEDINGS FOR REEXAMINATION AND REISSUE APPLICATIONS

In re Yousheng Shen, et al.
Reexamination Proceeding
Control No. 90/006,209
Filed: January 29, 2002
For: U.S. Patent No. 5, 650,054

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Mail Stop Reissue - Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL DECLARATION OF COMMERCIAL SUCCESS UNDER 37 C.F.R. § 1.132

Dear Sir:

I, Yousheng Shen, declare as follows:

1. I am the former Electrochemical Research Laboratory Manager for Atwood Mobile Products ("Atwood"). I was employed by Atwood from November 1994 to November 2007. My daily duties included development of new electrochemical-related products.

2. I am currently employed at Delta International as Engineering Director. I am being paid as a consultant by Atwood for assisting in the preparation and presentation of this Supplemental Declaration.

3. I received a doctorate degree in Material Science and Engineering from the University of Utah in 1994. My research as a doctoral candidate was directed towards ionic and electronic mixed conductors.

4. I understand that United States Patent No. 5,650,054 (the '054 Patent) and the related patent, United States Patent No. 5,573,648 (the '648 Patent) both are the subject of reissue proceedings in the United States Patent and Trademark Office. The reissue application of the '054 Patent is application no. 621,637 (the '637 Reissue Application). The reissue application of the '648 Patent is application no. 10/621,999 (the '999 Reissue Application). I am a named inventor on the '054 and '648 Patents.

5. The '054 and '648 Patents are directed to improved gas sensors. The '054 Patent is aptly titled "Low Cost Room Temperature Electrochemical Carbon Monoxide and Toxic Gas Sensor with Humidity Compensation Based on Protonic Conductive Membranes." Described in the specification of the '054 Patent are electrochemical gas sensors having a protonic conductive electrolyte membrane and sensing and counter electrodes with proton-electron mixed conductive material, with the counter electrode exposed to water vapor.

6. Claims 1, 126 and 128 are broadly representative of the claims in the '637 Reissue Application. Claim 1 reads:

> 1. An electrochemical gas sensor for quantitative measurement of a gas in a ambient atmosphere comprising:
>
> a sensing electrode permeable to water vapor and comprised of an electrical conducting material and having a surface exposed to the ambient atmosphere;
>
> a counter electrode permeable to water vapor and comprised of an electrical conducting material;
>
> a first protonic conductive electrolyte membrane permeable to water vapor and situated between and in contact with the sensing and counter electrodes, the sensing electrode reacting with the gas to produce a change in electrical characteristic between the sensing electrode and the counter electrode;
>
> means for electrical measurement electrically connected to said sensing and counter electrodes;

means, containing a volume of water vapor, for exposing a surface of said counter electrode to said water vapor, wherein the electrical conducting material of at least one of said sensing and counter electrodes is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material;

whereby, in a positive ambient atmosphere concentration of said gas, said electrical measurement means detects changes in said electrical characteristic.

Claim 126 of the '637 Reissue Application reads:

126. A residential electrochemical gas sensor for quantitative measurement of carbon monoxide gas in an ambient atmosphere comprising:

a sensing electrode permeable to water vapor and comprised of an electrical conducting material and having a surface exposed to the ambient atmosphere;

a counter electrode permeable to water vapor and comprised of an electrical conducting material;

a first protonic conductive electrolyte membrane permeable to water vapor and situated between and in contact with the sensing and counter electrodes, the sensing electrode being capable of reacting with the carbon monoxide gas to produce a change in electrical characteristic between the sensing electrode and the counter electrode;

means for electrical measurement electrically connected to said sensing and counter electrodes;

means, containing a volume of water vapor, for exposing a surface of said counter electrode to said water vapor,

wherein the electrical conducting material of at least one of said sensing and counter electrodes is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material;

whereby, in a positive ambient atmosphere concentration of the carbon monoxide gas at room temperature, said electrical measurement means is capable of detecting changes in said electrical characteristic.

Claim 128 of the '637 Reissue Application reads:

128. A two-electrode residential electrochemical gas sensor for quantitative measurement of carbon monoxide gas in an ambient atmosphere comprising:

a sensing electrode permeable to water vapor and comprised of an electrical conducting material and having a surface exposed to the ambient atmosphere;

a counter electrode permeable to water vapor and comprised of an electrical conducting material;

a first protonic conductive electrolyte membrane permeable to water vapor and situated between and in contact with the sensing and counter

electrodes, the sensing electrode and the counter electrode being the only two electrodes in contact with the first protonic conductive electrolyte membrane, and the sensing electrode reacting with the carbon monoxide gas to produce a change in electrical characteristic between the sensing electrode and the counter electrode in the absence of an applied voltage to the sensing electrode;

means for electrical measurement electrically connected to said sensing and counter electrodes;

means, containing a volume of water vapor, for exposing a surface of said counter electrode to said water vapor,

wherein the electrical conducting material of at least one of said sensing and counter electrodes is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material;

whereby, in a positive ambient atmosphere concentration of the carbon monoxide gas at room temperature, said electrical measurement means detects changes in said electrical characteristic;

wherein each of the sensing electrode and the counter electrode comprise a mixed protonic-electronic conductive electrode including platinum, carbon and a copolymer having a tetrafluorethylene backbone with a side chain of perfluorinated monomers containing a sulfonic acid group; and

wherein the protonic conductive solid electrolyte membrane is substantially comprised of a solid, perfluorinated, ion-exchange polymer.

7. I have examined examples of the commercial embodiments of the carbon monoxide (CO) sensors sold by the licensee (the "CO Sensors") at the beginning and throughout the licensing period on a periodic basis.

a) As a general overview, the CO Sensors detect CO, at room temperature under ambient atmosphere conditions, by detecting a change in an electrical current.

b) The CO Sensors have a sensing electrode and a counter electrode on opposite sides of a solid electrolyte membrane.

c) The sensing and counter electrodes are the only two electrodes in contact with this membrane.

d) The sensing electrode is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.

e) Specifically, the sensing electrode is made of platinum, carbon and a copolymer having a tetrafluorethylene backbone with a side chain of perfluorinated monomers containing at least one of a sulfonic acid group (hereinafter "Nafion®").

f) The platinum and the carbon in the sensing electrode are electronic conducting materials.

g) The Nafion® in the sensing electrode is an ionic/protonic conducting material.

h) Specifically, the sensing electrode includes 33 wt % of Nafion® and 13 wt % of a carbon-supported platinum.

i) The sensing electrode is 15 mm in diameter.

j) The counter electrode is a proton-electron mixed conductive material having 10-50 wt % of a proton conductor material and 50-90 wt % of a first and a second electrical conductor material.

k) The counter electrode is made of platinum, carbon and Nafion®.

l) The platinum and the carbon in the counter electrode are electronic conducting materials.

m) The Nafion® in the counter electrode is an ionic/protonic conducting material.

n) Specifically, the counter electrode includes 33 wt % of Nafion® and 13 wt % of a carbon-supported platinum.

o) The counter electrode is 15 mm in diameter.

p) The solid electrolyte membrane is a protonic conductive solid electrolyte membrane made of Nafion®.

q) The solid electrolyte membrane is 0.17 mm thick.

r) When the sensing electrode comes into contact with CO gas, ionized hydrogen atoms (i.e., protons) and electrons are produced. Both the protons and the electrons travel from the sensing electrode where they are produced to the counter electrode.

s) The protons travel via the solid electrolyte membrane to the counter electrode.

t) The electrons travel via an external electrical circuit to the counter electrode, thereby allowing the current generated by the sensing electrode to be measured.

u) A water vapor reservoir supplies water vapor to the sensing electrode, counter electrode and solid electrolyte membrane.

v) The sensing electrode and the counter electrode are both permeable to water vapor.

8. I have determined that the CO Sensors are covered by, at least certain of, the instant claims of the '637 Reissue Application.

a) The CO Sensors are electrochemical gas sensors for measurement (including quantitative measurement) of a gas in an ambient atmosphere (as recited, e.g., in the preamble of claims 1, 66-67, 73, 76-78, 126 and 128).

1) Specifically, the CO Sensors detect carbon monoxide (see the further limitations of claims 126 and 128).

2) Further, in the CO Sensors, the sensing electrode and the counter electrode are the only two electrodes in contact with the first protonic conductive electrolyte membrane (see, e.g., the further limitations of claims 66, 74, 76 and 128).

b) The CO Sensors have a sensing electrode and/or a counter electrode having proton-electron mixed conductive material (as recited, e.g., in claims 1, 66-67, 73, 76-78, 126 and 128).

1) The sensing electrode and the counter electrode are permeable to water vapor (as recite, e.g., in claims 1, 66-67, 73, 76-78, 126 and 128).

2) The sensing electrode and/or counter electrode include carbon and a noble metal (see, e.g., the further limitations of claims 12 and 128).

3) Specifically, the sensing electrode and/or counter electrode includes platinum, carbon and a copolymer having a tetrafluorethylene backbone with a side chain of perfluorinated monomers containing a sulfonic acid group (see, e.g., the further limitations of claim 128).

4) More specifically, the electronic and ionic conducting materials of the sensing electrode and/or counter electrode are a proton-electron mixed conductive material having 10-50 wt% of a proton conductor material and 50-90 wt% of first and second electrical conductor materials (see, e.g., limitations in claim 1, 66-67, 76-78, 126 and 128).

5) The proton conductor material for the sensing electrode and/or counter electrode is a copolymer having a tetrafluorethylene backbone with a side chain of perfluorinated monomers containing a sulfonic acid group (see, e.g., the further limitations of claims 11 and 128).

6) Even more specifically, one of the first and second electrical conductor materials for the sensing electrode and/or counter electrode is 50-99 wt% of carbon black, and the other of the first and second electrical conductor materials for the sensing electrode is 1-50 wt% of platinum (see, e.g., the further limitations of claim 12).

c) The CO Sensors have a first protonic conductive solid electrolyte membrane in between and in contact with the sensing and counter electrodes (see, e.g., limitations of claims 1, 66-67, 73, 76-78, 126 and 128).

1) Specifically, the protonic conductive electrolyte membrane is substantially comprised of a solid, perfluorinated, ion-exchange polymer (see, e.g., the further limitations of claims 9 and 128).

2) Further, the protonic conductive electrolyte membrane has a thickness in the range of approximately 0.1 mm to 1 mm (as recited, e.g., in claims 128 and 129).

3) Specifically, the protonic conductive electrolyte membrane has a thickness of approximately 0.17 mm (see, e.g., the further limitation of claim 130).

d) The sensing electrode of the CO Sensor is capable of reacting with the gas to produce a change in an electrical characteristic between the sensing electrode and the counter electrode (as recited, e.g., in claims 1, 66-67, 73, 76-78, 126 and 128).

1) Specifically, the sensing electrode is capable of reacting with carbon monoxide (CO) (see, e.g., the further limitations of claims 126 and 128).

2) Further, the sensing electrode reacts with the gas to produce a change in an electrical characteristic between the sensing electrode and the counter electrode in the absence of an applied voltage to the sensing electrode (see, e.g., the further limitations of claim 128).

e) The CO Sensor includes means for electrical measurement that are electrically connected to the sensing and counter electrodes (as recited, e.g., in claims 1, 66-67, 73, 76-78, 126 and 128).

f) The sensing and counter electrodes each having a diameter in the range of approximately 1 mm to 15 mm, and are electrically connected to the electrical measurement means (as recited in claim 129).

1) Specifically, the sensing and counter electrodes have a diameter of approximately 15 mm (see, e.g., the further limitations of claim 130).
2) The electrical measurement means is capable of detecting changes in the electrical characteristic in a positive ambient atmosphere concentration of the gas at room temperature (see, e.g., the further limitations of claims 126 and 128).
3) In a positive ambient concentration of the gas at room temperature, the electrical measurement means is capable of detecting changes in the electrical characteristic in the absence of any biasing voltage (see, e.g., the limitations of claim 73).

g) The CO Sensors include means, containing a volume of water vapor, for exposing a surface of said counter electrode to said water vapor (as recited in all of the claims).
h) The sensing and counter electrodes are each permeable to water vapor (as recited in all of the claims).

9. As set forth in the specification of the '637 Reissue Application, the invention represents significant improvements over prior art carbon monoxide and toxic gas sensors. Commercial embodiments of the claimed invention, manufactured by Atwood's licensee under the patent, i.e., the CO Sensors, exhibit many commercially significant improvements over prior art carbon monoxide sensors:
   i) the CO Sensors operate reliably at room temperature with part per million (ppm) accuracy and resolution;
   ii) the CO Sensors do not need recalibration (keeping their ppm accuracy and resolution) during their lifetime (typically 5 years or more);
   iii) the CO Sensors, themselves, do not consume any power;
   iv) the CO Sensors have an improved ppm CO detection accuracy and resolution; and
   v) the CO Sensors are cheaper to manufacture at a dollar cost.

10. The commercial advantages listed in Section 9 are related to and made possible by the following technical performance properties and claimed features:

i) the CO Sensors operate reliably and rapidly at room temperature, in part, because of their strong current signal output in response to detection of CO, which is due to the combination of:

a) the sensing electrode, the counter electrode and the solid electrolyte membrane all including a protonic conductor, and thereby having a minimal ionic/protonic (H^+) resistance between the electrodes and between the electrodes and the electrolyte; and further

b) the use of mixed ionic-electronic conductive sensing and counter electrodes, thereby providing a high surface area for three-phase interface contact to occur; and further

c) the use of a sensing electrode, a counter electrode and an electrolyte membrane that are permeable to water vapor and the use of a water vapor reservoir, thereby providing a reduced resistance to the protonic conductivity over the life of the CO Sensor.

ii) the CO Sensors do not need recalibration during their lifetime (typically 5 years or more), because their baseline calibration of 0 ppm of CO *(i.e.,* clean air) does not shift regardless of high temperatures or contamination of the electrolyte and because the continuity in transport of electrical charges avoid polarization effects at the electrodes, which are due to the combination of:

(a) operating at room temperature; and further

(b) having a solid electrolyte membrane; and further

(c) the use of mixed ionic-electronic conductive sensing and counter electrodes, thereby providing a high surface area for three-phase interface contact to occur.

iii) the CO Sensors, themselves, do not consume any power because they do not require a reference electrode and amplifier, thereby eliminating the need for applied DC power to drive the detection current, which is due to the combination of:

a) the sensing electrode, the counter electrode and the solid electrolyte membrane all including a protonic conductor, and thereby having a minimal ionic/protonic (H^+)

resistance between the electrodes and between the electrodes and the electrolyte; and further

b) the use of mixed ionic-electronic conductive sensing and counter electrodes, thereby providing a high surface area for three-phase interface contact to occur; and further

c) the use of a sensing electrode, a counter electrode and an electrolyte membrane that are permeable to water vapor and the use of a water vapor reservoir, thereby providing a time stable, constant humidity environment for all of the sensor's components, including the electrodes and the electrolyte, as well as providing a reduced resistance to the protonic conductivity over the life of the CO Sensor.

v) the CO Sensors have an improved ppm CO detection accuracy and resolution because of their strong current signal output in response to detection of CO and because there is no significant diffusion of contaminating hydrogen molecules, which are due to the combination of:

a) the sensing electrode, the counter electrode and the solid electrolyte membrane all including a protonic conductor, and thereby having a minimal ionic/protonic (H^+) resistance between the electrodes and between the electrodes and the electrolyte; and further

b) the use of mixed ionic-electronic conductive sensing and counter electrodes, thereby providing a high surface area for three-phase interface contact to occur; and further

c) the use of a sensing electrode, a counter electrode and an electrolyte membrane that are permeable to water vapor and the use of a water vapor reservoir, thereby providing a time stable, constant humidity environment for all of the sensor's components, including the electrodes and the electrolyte, as well as providing a reduced resistance to the protonic conductivity over the life of the CO Sensor; and further

d) having a solid electrolyte membrane.

vi) the CO Sensors are cheaper to manufacture, for example, by using an automatic insertion production line at 30 products per minute, due to the combination of:

a) not needing a reference electrode, an amplifier, a DC power source for the CO Sensor, itself; and further

b) the simplicity of using a solid electrolyte membrane.

Each of the above-listed technical performance properties, which make the licensed CO Sensor commercially successful, result from the inventive geometry and selection of materials claimed in the '637 Reissue Application. As presented above, these interrelated technical performance properties are directly attributable to limitations in the claimed subject matter of the '637 Reissue Application.

11. From my communications with Atwood executives, (and/or that of its former corporate parent, Dura Automotive Industries, Inc.), I am informed and believe that the '054 Patent and the '648 Patent are the subject of a royalty-bearing license agreement ("License") entered into in June 1998. The License is an arms-length agreement between separate corporate entities. I am further informed and believe that Atwood has received royalty payments and royalty reports pursuant to the License that set forth the number of CO Sensors sold by the licensee under the License.

12. I am informed and believe that patented CO Sensors were first sold under the License in November 1998; that according to such royalty reports, 1,991,639 patented CO Sensors were sold under the License in 1999, the first full year under the License; that according to such royalty reports, 2,717,913 patented CO Sensors were sold under the License in 2001, which represented over a 26.7% increase in sales over the three-year period from 1999 to 2001.

13. I am informed and believe that Atwood has continued to receive substantial royalty payments under the License for sales of patented CO Sensors. I am informed and believe that royalty payments under the License since 2001 have amounted to:

2002	$536,845
2003	$677,387

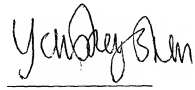
2004	$889,961
2005	$815,620
2006	$989,744
2007	$674,741

In other words, royalty payments received after 2002 have exceeded four million five hundred thousand dollars ($4,500,000).

14. I believe that the market share of the licensed CO Sensor in North America today is about 70% of the total market share of residential carbon monoxide sensors.

15. The commercial success of the patented CO Sensors sold pursuant to the License is directly attributable to the advantageous features set forth above in this declaration, which are directly attributable to the features claimed in the '637 Reissue Application.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with knowledge that willful false statements, and the like, so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-referenced patent.



Date: November 21, 2008

Dr. Yousheng Shen